Chapter-1

INTRODUCTION

1.1.1 Bangalore is the capital city of the southern Indian state of Karnataka. it is the seventh largest city in India. It is also known as the Garden City because of its many beautiful gardens and parks. Though the origin of Bangalore is ancient, the present-day city was founded in the 16th century and has since continued to be an important administrative center. Because of high concentration of IT industry, it also the silicon city if India. Bangalore is rated to one of the fastest growing cities in Asia with a current population of more than 6 million. During the last couple of decades, city has witnessed drastic increase in population, change in land use pattern of the city, life style of the people and their commuting habits and the revolutionary changes that has taken place in the automobile industry. This has contributed to the growth of vehicular traffic in an enormous way.

1.1.2 The vehicle population in all cities in India started rapidly since later part of 1980s. Bangalore is no exception. It is always had a reputation of having more two wheeler users. The liberalization policy of the country made availability of not only vehicles but also loans for buying vehicles. With the rapid growth of IT sector in Bangalore, the affordability of larger segment of employees increased for ownership of vehicles, more specially two wheelers. Coupled with inadequacy of comfortable and convenient public transport gave an impetus to more and more commuters shifting to cars and two wheelers for their commuting in Bangalore. The number of annum. The two wheelers, which constitute about 72% of the total registered vehicles, are growing at a rate of about 13% per annum. lately, cars have been growing even faster than two wheelers. Vehicle ownership has grown from 58 to 365 per 1000 population. The trend is likely to continue. This will result in higher use of personalizes modes of transport particularly cars unless extensive and convenient public transport system is provided.

1.1.3 The combined effect of all these on the road network of Bangalore is delay and congestion beyond tolerable limits. Vehicular conflicts at the intersection are being elimination by traffic signals but at the expense of delay and long queues. The peak hour has spread over a longer period of time, since there are no perceptible capacity augmentation/ conflict reduction measures.

1.1.4 In view of the above facts, road commuters are experiencing in-convenience and increased road user cost due to increase in the following factors.

- Intra city commuting time.
- Traffic congestions.
- Number of junctions & intersections.
- Junction delays.
- And increased rate of accidents, health hazards etc.

Hence, there is an urgent necessity to decongest these roads and intersections

Scanned by TapScanner

1.1.5 As comprehensive development programme for improvement of road network, the Bruhat Bengalore Mahanagar palike (BBMP) has planned improvements to Junction, widening/ improvement of roads, strengthening of pavement base and sub - base, improvement to pedestrian facilities, improvements to Drainages Facility, etc. This response is the answer to the severe strain on the urban infrastructure, which is inevitable due to the very rapid rate of growth in traffic. travel demands of passengers have increased many folds in the last two decades. Unfortunately growth in the infrastructure is not commensurate with the growing demands of traffic. There is an exigent need to effectively manage the traffic and transportation systems to optimize the solution with short term and long- term measures.

1.2 Project Location

The Project includes Restoration of Roads and drains Damaged Due to Traffic and weathering action Improvements to widen portion of roads, construction of new drains, UG cable duct and footpath at Doddabommasandra main road and surrounding road in Ward No.10. The Project area is located near in Yelahanka Part of Bangalore City. The Project area is located in thickly populated Residential/ Commercial area. The Project Stretch Started Improvements to widen portion of roads, construction of new drains, UG cable duct and footpath at Doddabommasandra main road and surrounding road in Ward No.10.Key Map of the roads proposed is enclosed in

1.3 Scope of Work

The Scope of Services of the Consultancy includes the following:

- ❖ Inventory and condition surveys for existing road & pavement, cross drainage structures and bridges.
- ❖ Identification of possible improvement of the existing alignment, central widening/ one side widening etc.
- ❖ Overlay/Flexible Pavement Design.
- ❖ Rate analysis of scheduled items, BOQ and cost estimates.

1.4 Contents of the Report

The Methodology, as detailed in the project proposal, has been followed for carrying out the necessary investigations and preparation of Detailed Estimate and Report.

This Report includes the following.

- ❖ Chapter 2 : Inventory
- ❖ Chapter 3 : Design Standards
- ❖ Chapter 4 : Analysis, Designs and Improvements
- ❖ Chapter 5 : Cost Estimates
- ❖ Chapter 6 : Conclusion

Scanned by TapScanner

Chapter – 2

ENGINEERING SURVEYS AND INVESTIGATIONS

2.1 General

Various surveys and investigations that are essential inputs for detailed engineering design are detailed in this chapter. All the relevant maps/ data/ details available with the concerned departments have been collected, compiled and reviewed. Particular attention has been given to past / historical data / reports. A review of the past data available in the various studies has been listed out and such available data has been made use of, after updating / augmenting the data wherever necessary. The data as collected has been made use of in analysis, design, formulation of improvement proposals and costing. The activities have been performed on several fronts fully complying with the requirements. The activities that are carried out are succinctly brought out hereunder.

The various engineering surveys / investigations of the road sections include:

- Reconnaissance Survey.
- Visual Topographical Survey.
- Road Inventory Survey.
- Pavement Condition Survey.
  - Visual Condition Survey.
  - Benkelman Beam Deflection
  - Geotechnical Investigation

2.2 Reconnaissance Survey

Reconnaissance Survey of the road, considered for improvements, has been carried out to identify the general condition of roads, drains, culverts and bridges for further surveys / investigations, to understand kind of establishments along the stretches of roads and to work out land acquisition scheme. Making use of the observations / data collected during reconnaissance survey, detailed schedule for surveys / investigations required for the project has been finalized.

2.3 Visual Topographical Survey

Topographic Survey has been conducted all along the Corridor by physically measuring the Road Width, Footpath Width, Drain Width, Alignment of Road and with the aid of Google Maps. Topographical Map of the project stretch is enclosed.

Scanned by TapScanner

2.4 Road Inventory Survey

A detailed inventory and condition survey of road sections has been carried out by making use of well structured inventory data format. It was compiled in tabular form, developed using Excel computer software. Various data collected during the road inventory broadly include.

- Type of terrain.
- Land use.
- Carriageway width.
- Type of surfacing.
- Shoulder, Median, Drain (tertiary / shoulder), Footpath – type and width.
- Road Geometry.
- Road Furniture.
- Illumination.
- Salient Buildings & Structures.
- Road intersection(s) and their details.
- Land width (ROW)
- Culverts, bridges and other structures (type, size, span arrangement, and location).
- General drainage conditions.

2.5 Pavement Condition Survey

The pavement Condition Survey has been carried out in accordance with IRC Guidelines. All surveys and investigations have been carried out with the following objectives

- To have an up to date record of road assets.
- To have a clear understanding of road side features including land use, drainage characteristics, etc. and
- To assess the condition and strength data for developing improvement proposals and related designs.

2.5.1 Visual Condition Survey

Visual Condition Survey of the road sections has been carried out by travelling along the project road and noting down the pavement conditions such as extent of cracking, patching, rutting, pot holes, edge breaking, etc. by visual observations in a well structured data format. The data so collected has been comiled and presented (Road wise) in the form of tables for easy understanding. This data has been used to assess the pavement condition.

2.5.2 Benkelman Beam Deflection

The objective of the Benkelman Beam Deflection (BBD) technique is to assess the structural strength of existing pavement and to determine the requirements of strengthening of flexible pavements. Performance of flexible pavements is closely related to the elastic deflection of

Scanned by TapScanner

pavement under wheel loads. The deformation or elastic deflection under a given load depends upon parameters like sub grade soil type, its moisture content and compaction, the thickness and quality of the pavement layers, drainage conditions, pavement surface temperature etc.

The deflection survey is carried out as control section testing

The control section testing involves carrying out deflection testing for every 100m long homogeneous road segment along the road sections. The selection of homogeneous segment was based on the data derived from the pavement condition surveys. BBD testing was carried out as a minimum of 100m stretch chosen from each kilometer. The deflection measurements for the control section testing were conducted at an interval of not more than 10m.

2.5.3 Sub-Grade Characteristics and Strength

The data relating to soil classification and mechanical characteristics for soils along the existing alignments were collected.

For the widening of the existing road within the ROW, testing is being performed on at least three sub-grade soil samples for each homogenous road segment or three samples for each soil type encountered whichever is more.

The sub-grade soil is being tested as follow:

- In- situ density and moisture content at each test pit.
- Field CBR at each test pit.
- Characterization (grain size and Atterberg limits) at each test pit.
- Laboratory moisture-density characteristics (modified AASHTO compaction).
- Laboratory CBR (unsoaked and 4-day soak, compacted at three energy levels) and swell.

Objective

The objective of the investigations is to provide basis for design of various types of pavements viz. pavement option study for the project road, keeping in view the composition and characteristics of the existing pavement/sub grade. The scope of work thus includes:

- Collection of information regarding the existing pavement crust composition and characteristics.
- Existing sub grade type and sub-soil conditions

Methodology for sub-grade soil and pavement crust investigations

Test pits of approx. 1.0m x 1.0m size staggered along the edge of the existing pavement on both sides are excavated up to sub grade level (up to 1.5m depth) at regular intervals along the road alignment. These test pits are excavated on shoulders extending about 20cms into the pavement.

Scanned by TapScanner

(71)

Bulk sample of about 30kg was collected from all the test pits at natural ground level to analyze the characteristics of the existing sub grade material. Field Density tests were conducted for all the test pits and also the natural moisture content were determined at each test pits.

The following laboratory tests were conducted for all the samples collected from the test pit.

- Grain size analysis (As per IS: 2720 – Part4).
- Atterberg limits test (AS per IS: 2720 – Part5).
- Standard proctor tests (As per IS: 2720 – Part8)
- Soaked CBR tests (4 – days soaked).

Laboratory Test Results of Soil Samples

The soil samples of the sub grade collected from the test pits are tested in the laboratory and the test results for Grain size classification, Atterberg limits, MDD, corresponding OMC and CBR values etc. are attached.

Geotechnical investigation Report is enclosed.

2.6 Traffic Surveys

The program me for traffic studies and the location of traffic surveys have been finalized after reviewing in detail the available traffic data. Particular attention has been paid to identify gaps and further data requirements of the study. The traffic surveys have been designed for filling up data gaps as well as updating the information. The locations of the survey stations have been reviewed considering the suitability of various type of traffic surveys. Traffic surveys have been carried out at selected locations for updating the traffic information. Following surveys have been conducted:

- Traffic Volume Count
  These surveys have been carried out in accordance with IRC: SP-19-2001 and IRC: SP-41-1994. The study details of hourly traffic volume count are enclosed.

2.6.1 Traffic Volume Count

For ascertaining the present traffic flows on various road stretches, classified traffic volume counts have been undertaken to ascertain the type and number of operating vehicles. Data has been analyzed to identify peak hour flows and composition of traffic. PCU factors are as per IRC: 106 – 1990 "Guidelines for capacity of urban roads in plain areas". These field surveys carried out in a scientific manner have led to a realistic data bank based on which the design and cost of construction of the pavement is being developed. Data derived from the survey has been analyzed to identify requirement of suitable remedial measures such as junction improvements; widening of ROW; pedestrian crossings etc.

Scanned by TapScanner

Chapter - 3

DESIGN STANDARDS

3.1 General

Planning and design of roads & CD structures, pedestrian facilities and street furniture are essentially based on the IRC standards and MoRT&H specifications. Whenever, the codes / standards are silent on some of the aspects, the same has been planned/ designed based on sound engineering practices. Design standards relevant to the project road along with the broad list of design parameters and the relevant IRC codes/ specifications have been detailed in **Table 3.1.**

Table 3.1

Design Standards

Sl. No.	Design Parameters	Reference Code
1.	**Geometric Design Standards** • Carriageway width • Shoulder • Footpath • Median • Camber • Super Elevation • Horizontal Alignment • Vertical Alignment	As Per IRC : 38-1988, IRC: 86-1983 & IRC : SP: 23-1993
2.	**Road Furniture** • Road Delineators • Road markings • Road Signs	As per IRC: 79-1981 As per IRC: 35-1997 As per IRC: 67-2001
3.	Road capacity	As per IRC: 106-1990
4.	Flexible pavement Design	As per IRC: 37-2012
5.	Overlay Design	As per IRC: 81-1997
6.	Road drainage	As per IRC: SP: 42 - 1994 & IRC : SP:50- 1999
7.	Culverts	As per relevant IRC codes and MoRT&H specifications
8.	Bridges	

The project road section passes through plain terrain. Design standards (as appropriate) have been further elaborated under the following heads:

- ❖ Geometric Design
- ❖ Overlay Design
- ❖ Drainage
- ❖ Road Furniture and Appurtenances

Scanned by TapScanner

- Bridges and CD Structure

3.2 Design Standards Related to Geometric Design

Design standards related to road geometric along with the suggested design values / standards and recommended values based on site conditions and data analysis are detailed in.

Table 3.2

Table 3.2

Geometric Design Standards

SL. NO	Design Parameters	Design Values
1.	Design Speed	Design Speed Considered is 40kmph.
2.	Geometric Design Standards	
	• Carriageway Width	Two lane carriageway.
	• Camber (BI - directional)	2.5%for paved carriageway.
	• Super Elevation **	Limited to 4%
	• Footpath	Minimum Width -1.5%
	• Kerb	Barrier / Semi - barrier / mountable (Barrier type recommended)
	• Minimum radius of Horizontal Curve	40 m for a speed of 30 kmph 105 m for a speed of 50 kmph
	• Extra Widening at Curves	Nil for Radius above 300 m
	• Gradient	Maximum Gradient - 4.0% (1 in 25) Minimum Gradient for Drainage - 0.5 % (desirable minimum) & 0.3 % (absolute minimum)

(*- Reference Code: IRC: 86 - 1983 "Geometric Design Standards for Urban Roads in Plains")

3.3 Design Standards Related to Overlay Design

Design Standards Related to Overlay Design are essentially based on the guidelines given in IRC: 81 - 1997 'Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique". The suggested design values / standards and recommended values based on site conditions and data analysis detailed in table 3.3. and are adapted in the design.

Scanned by TapScanner

Table 3.3

Overlay Design Standards

SL. NO	Design Parameters	Reference Code/Design Values
1.	Overlay Design	IRC: 81 -1997 "guidelines for strengthening of flexible road Pavements using Benkelman Beam Deflection Technique"
	• Design Life	10 years
	• Correction Factors	Temperature Correction Factor. Correction for Seasonal Variation (inclusive of correction for moisture content, soil type and rainfall)
	• Minimum Thickness	From structural considerations recommended minimum bituminous overlay thickness is 40 mm AC (minimum) or 50 mm BM (as required)+ 40 mm BC
2.	Wearing Course Material (Options)	Bituminous Concrete with Crumb Rubber Modified Bitumen / Plastic Waste.

3.4 Design Standards Related to Road Drainage

Drainage of water from pavement surface is of paramount importance as far as preserving the road assets created by investing huge funds in addition to maintaining the structural soundness and functional efficiency of the road. Design standards related to road Drainage are essentially based on the guidelines given in IRC: 42-1994 "Guideline on Road Drainage" and in IRC: SP: 50-1999 "Guidelines." on Urban Drainage." the suggested design values / standards are detailed in **Table3.4.**

Table 3.4

Design Standards Related to road Drainage

SL. NO	Design Parameters	Design Values
1.	• Camber	1.7 - 2.5 % (bi - directional) for carriageway (camber of 3% is adopted).
	• Longitudinal Gradient	Minimum 0.3 - 0.5 % for satisfactory drainage
	• For Existing Drains	Desilting and Rectification of Damaged Portion

3.5 Design Standards Related to Road Furniture and Appurtenances

Utility and importance of the road are greatly enhanced by installing road furniture and appurtenances at appropriate locations along the project road, which ensures improved road safety. planning and design of road furniture and appurtenances are as per the guidelines stipulated in IRC. Detailing of each of these components has been

Scanned by TapScanner

done so as to integrate the same with the road improvement scheme. The suggested design values / standards are detailed in **Table3.5**

Table 3.5

Design Standards Related to Road Furniture and Appurtenances

SL. NO	Design Parameters	Reference Code/Design Values
1.	Road Markings	IRC: 35 - 1997 "Code of practice for Road Markings"
2.	Road Signs	IRC: 67 - 2001 "Code of practice for Road Signs".
3.	Road Delineators	IRC: 79 - 1981 "Recommended Practice for Road Delineators."
4.	Pedestrian Facilities	IRC: 103 - 1988 "Guidelines for Pedestrian Facilities".

In addition to the above measures various other integral road components have been planned so as to achieve the maximum and optimal use of the carriageway with no / least interference to traffic flow at the same time ensuring adequate facilities to other road users especially pedestrian. All the encroachments, if any shall be cleared within the Row.

3.6 Design Standards Related to Bridges and CD Structures

The design standards and loading considered for culverts and bridges are as stipulated in latest IRC code / Special publications supplemented by appropriate MOST circulars and / or IS codes. The unsafe and / or deficient bridge and culvert structures (existing) will be rehabilitated or replaced by sound structure.

Scanned by TapScanner

Chapter 4

ANALYSIS, DESIGN AND IMPROVEMENTS

4.1 General

Improvement proposals for an existing road sector essentially consist of two components, geometric and structural improvements. Geometric improvement deals with visible dimensions of roadway, probable road widening and a dictated by the traffic and economic considerations. Due to the inherent restrictions like limitations in land acquisition, limited right of way and existing utilities /services, etc the horizontal and vertical alignments in general follow the existing geometry except in situations where improvements are possible. The geometric improvements mainly involve improvements to cross sectional elements such as carriageway, shoulders, etc. The structural component deals with the pavement and embankment design aspects, i.e., the ability of the roads to adequately carry and support the vehicle / wheel loads over the design period. Safety, speed, efficiency, economy and comfort in traffic movement to a large extent are governed by adequacy or design standards used for a specific road facility.

The improvement proposals need to consider the method of widening like concentric or eccentric to the existing road which is dictated by site situations like available land for acquisition, curvature, existing utilities, terrain, places of work ship, monuments, grave yards, places of importance etc.

This chapter deals with the analysis of data collected during various engineering surveys/ investigations and the formulation of improvement proposals including planning and design.

4.2 Road inventory and Physical Characteristics of Road Section

Investigations/ studies have been carried out along the Project Stretch. Physical characteristics of these road and junction are as follows.

The project includes Improvements of Improvements to widen portion of roads, construction of new drains, UG cable duct and footpath at Doddabommasandra main road and surrounding road in Ward No.10. The Project area is located in thickly populated Residential / Commercial area.

Project Stretch considered for improvement of roads is 6.35 Km.

Width of Carriageway along the Road various from 4.10 m to 9.70 m. Width of ROW various from 5.3 m to 10.90 m.

The Road carries considerable vehicular traffic throughout the day especially during peak hours. Considerable pedestrian traffic is also present along the corridor.

Scanned by TapScanner

4.3 Benkelman Beam Deflection Results

Benkelman Beam Deflection tests cannot be conducted for the project stretch as the road has many longitudinal and cross cuttings. Hence it is proposed to strengthen / reconstruct the road from sub base.

4.4 Summary and Recommendations

To obtain the Geotechnical and Materials characteristics of project stretch, an extensive study of the existing pavement sub-base, local borrow areas for embankment were carried out. Accordingly the entire stipulated tests have been performed and the summary of tests results along with the recommendations has been attached.

- ❖ The CBR value of existing sub grade of the Road varies between 8.0% and 8.1%

4.5.1 Analysis of Traffic Data

Data was processed on hourly basis to establish the peak hours. Data collected from surveys were computerized and analysis to study hourly variation of traffic, peak hour flows, traffic composition, etc. The counts were classified by category of vehicles and by direction of movement. The various vehicle types having different sizes and characteristics were converted into equivalent passenger car units. The passenger Car Unit (PUC) factors recommended by Indian Road Congress in "Guidelines for Capacity of urban Roads in plain Areas" (IRC: 106- 1990) have been. The same are detailed in **Table 4.2**

Table 4.2

Recommended PUC factors for Various Types of Vehicles on Urban Roads

Vehicle Type	**Equivalent PUC Factors**	
	% Composition of Vehicle type in Traffic stream	
	Up to 10%	**10% and above**
Fast Moving Vehicle		
Two wheelers, Motors cycle or Scooter, etc.	0.5	0.75
Passenger Car, Pick up Van	1.0	1.0
Auto-rickshaw	1.2	2.0
Light Commercial Vehicle	1.4	2.0
Truck or Bus	2.2	3.7
Agricultural Tractor Trailer	4.0	5.0
Vehicle Type	**Equivalent PUC Factors**	
	% Composition of Vehicle type in Traffic stream	
	Up to 10%	**10% and above**
Slow Moving Vehicle		
cycle	0.4	0.5
cycle rickshaw	1.5	2.0
Tonga (Horse drawn Vehicle)	1.5	2.0
Hand cart	2.0	3.0

Scanned by TapScanner

(Source: IRC: 106 - 1990)

4.5.2 Design Traffic

Peak hour traffic is taken as design hour traffic for urban roads. maximum of morning and evening peak flow is taken as design hour traffic.

4.5.3 Cumulative Standard Axles for pavement Design

Traffic projections available from traffic study have been used for design of pavements. The design traffic is considered in terms of cumulative numbers of standard axles to be carried during the design life of the road. Its computations involves estimates of the initial volume of commercial vehicle per day, lateral distribution of traffic, the growth rate design life in years and the vehicle damage factor to convert commercial to standard axles.

The following equation is used to compute the design traffic in terms of the cumulative number of standard axles.

$$Ns = \frac{365x[(1+r)n-1]}{r} xAxdxF$$

Where,

Ns= Cumulative number of standard axles to be catered for i the design

A= Initial Traffic, in terms of commercial vehicle per day modified to account for lane distribution.

r=Annual growth rate of commercial vehicle (Growth rate adopted as per the recommendation Chapter 3).

n=Design life in years (10 years)

F= Vehicle damage Factor

The design traffic computed in terms of cumulative numbers of standard axles (msa).

4.6 Pavement Design

The following guidelines have been followed for design of new pavement and for design of overlays for the existing pavements.

- AASHTO guide for design of pavement structures, 1993.
- Guidelines for design of flexible pavements 1RC-37, 2001.
- IRC: 81 - 1997 Guidelines for Strengthening of Flexible Road Pavement using Benkelman Beam Deflection Technique.

Scanned by TapScanner

63

4.6.1 Design of Flexible Pavement for Widened / damaged Portion

The following inputs are considered for designing the flexible pavement as per IRC guidelines.

- ❖ Design Traffic in terms of cumulative number of standard axles (msa)
- ❖ Annual Average Pavement temperature is taken as 350C.
- ❖ Sub grade strength is considered in terms of the CBR value.

Using the design CBR value and the cumulative standard axle load, total pavement thicknesses have been obtained from the design charts given in IRC: 37-2012.

230mm Wet Mix Macadam, 50mm Bituminous Macadam and 40mm Bituminous Concrete.

Pavement Design Report is enclosed

4.4 Proposed Improvements to Road Section

The proposals for the improvement of the geometric elements of the existing project road sections generally include:

a. Geometric Improvements
- ❖ Maintaining Uniform Carriageway.
- ❖ Improvements to cross sectional elements

b. Strengthening of Existing Pavement
- ❖ 230mm Wet Mix Macadam
- ❖ 50mm Bituminous Macadam and 40mm Bituminous Concrete

c. Road Furniture and Appurtenances
- ❖ Providing Lane Marking

Scanned by TapScanner

62

Chapter – 5

COST ESTIMATES

5.1 Detailed Cost Estimate

Detailed cost Estimate has been worked out based on detailed engineering design

5.2 General

Cost Estimate is an important part of the Report as it provides vital input to financial evaluation of the project. The cost estimates have been prepared for Strengthening of the existing road including strengthening of longitudinal drains, road furniture, site clearance and Dismantling.

5.3 Basic rates

As part of Report, Rate Analysis of each of the item has been prepared by adopting PW, P &IWTD SR 2018 -19, Bangalore Circle. The rates as given in PW, P & IWTD SR are to be enhanced by 6% for additional weightages for the works to be executed under extra ordinary conditions for Bangalore Metropolitan Limits and for Construction cost adding 12 % GST.

5.4 Project Management and Quality Control

Provision of Lump sum cost of 2% of Construction Cost has been made towards Cost of Quality Control, PMC and Proof Checking and 0.5% total cost provision is made for preparation of DPR.

5.5 Project Cost

The total project cost for the proposed work is 275.**00 Lakhs**

Detailed Cost Estimate is enclosed

Assistant Engineer
Project Yelahanka
Ward no.25

VSR CIVIL INFRA PVT. LTD BANGALORE

Asst Executive Engineer
Project Yelahanka

Executive Engineer,
Project Yelahanka
BBMP

Scanned by TapScanner